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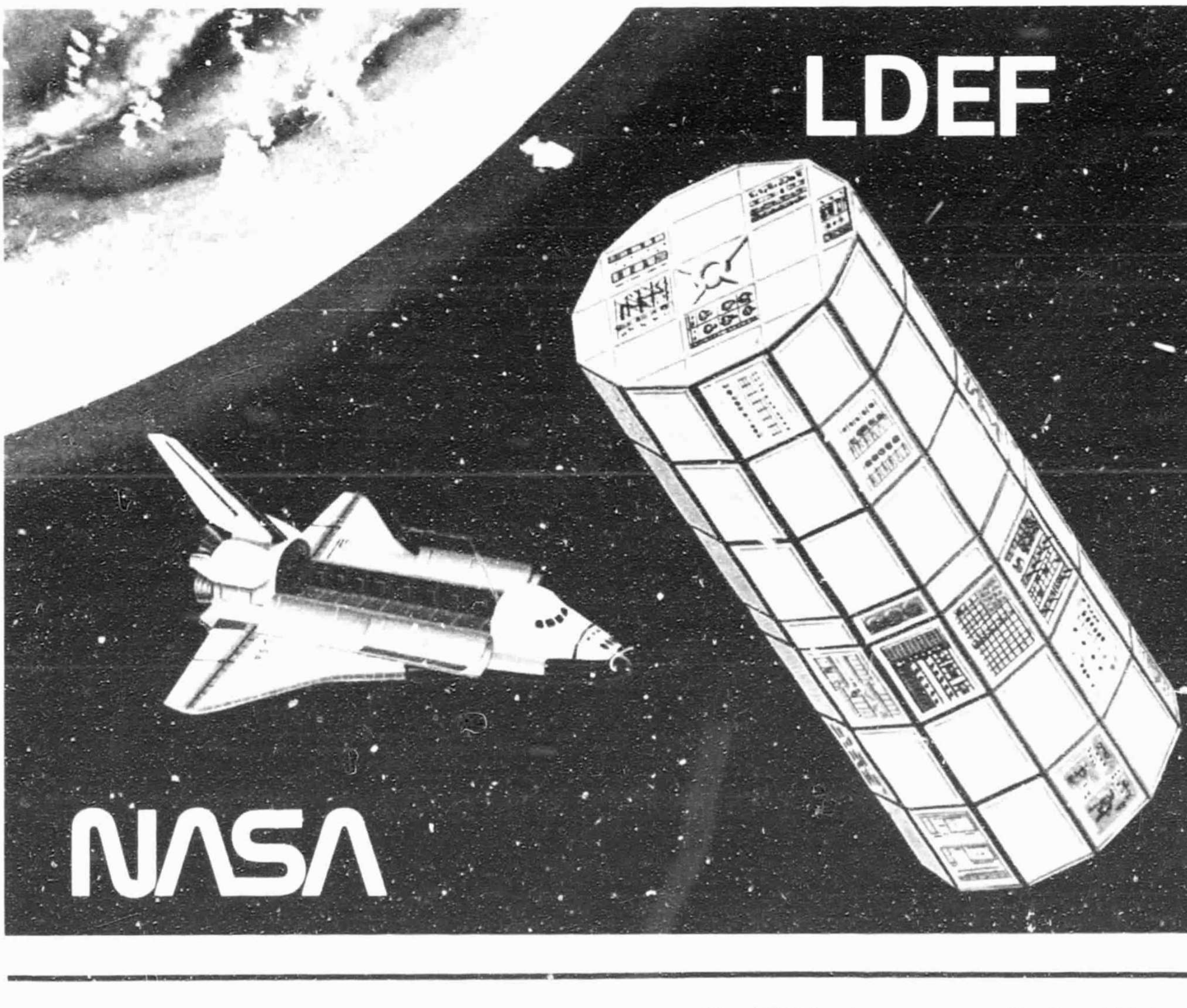
A New Dimension in Space Experimentation



The Space Shuttle has brought a totally new dimension to space travel and to the possibilities for scientific experimentation in space. The Long Duration Exposure Facility (LDEF) provides a bold new opportunity for scientific research which will take advantage of the Shuttle's ability to place payloads in space and later retrieve them.

The LDEF is a large, unmanned facility which inexpensively accommodates numerous technology, science and applications experiments requiring a free-flying exposure in space. The reusable, 12-sided structure is approximately 14 feet (4.3 meters) in diameter and 30 feet (9.1 meters) long, just the right size to comfortably fit in half of the Shuttle's payload bay. LDEF will be placed in orbit by the Space Shuttle during its spring 1984 mission.

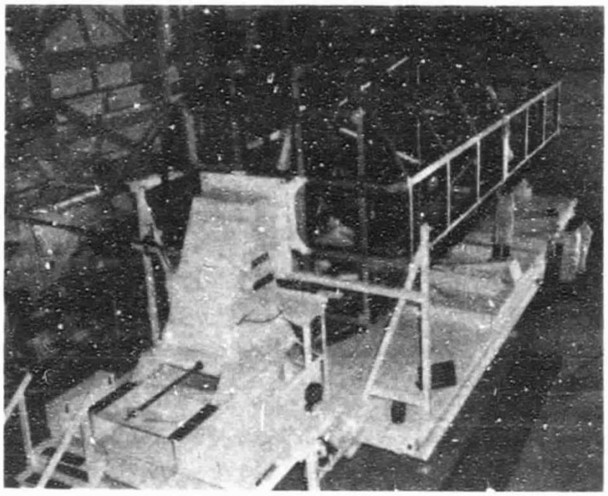
A New Dimension in Space Experimentation

Fifty-three scientific and technological experiments developed by more than 200 investigators from universities, private industry and government laboratories are participating in the first LDEF mission. LDEF contains 86 trays into which experiments are mounted. Each experimenter received one or more trays, approximately 50 inches (127 cm) long and 38 inches (96.5 cm) wide, with depths of 3, 6, or 12 inches (7.6 cm, 15.2 cm and 30.5 cm), into which his/her experiment was placed. The loaded trays were then sent to NASA for placement on LDEF. After the flight, the experiments will be returned to the individual experimenters for laboratory analysis. Guidelines for LDEF experiments included modest electrical power and data processing requirements and the ability to benefit from postflight studies.

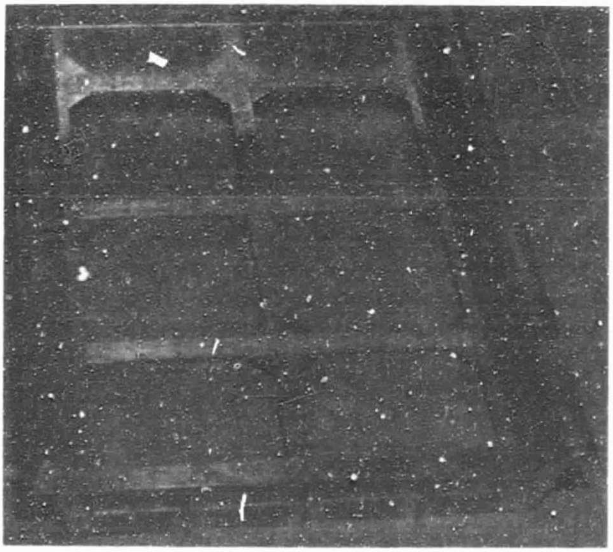
The Shuttle's remote manipulator system will remove the LDEF from the payload bay. Before release, the LDEF's longitudinal axis will be aligned with the local Earth vertical axis. After careful orientation, the gravity-stabilized facility will be released in space in a low-Earth orbit about 300 miles (482 kilometers) above the Earth's surface.

After approximately one year in space, the LDEF will be retrieved by the Shuttle and returned to Earth.

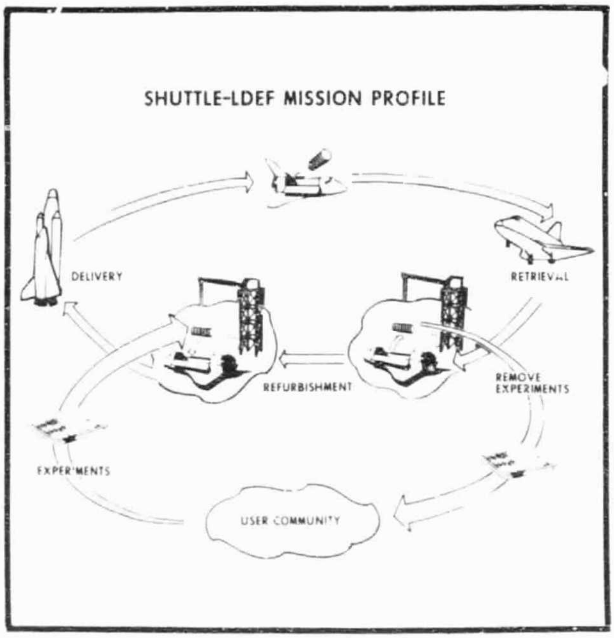
The LDEF opportunity is an exciting one for investigators. As a retrievable spacecraft, it allows investigators to gather data over a long period of time and have their experiments returned to them for in-depth analysis. This greatly increases the kinds of testing that can be done and the number of investigators who can be involved.



The LDEF undergoes final checkout at NASA's Langley Research Center prior to shipment to Kennedy Space Center for experiment tray integration.



Typical LDEF Experiment Tray



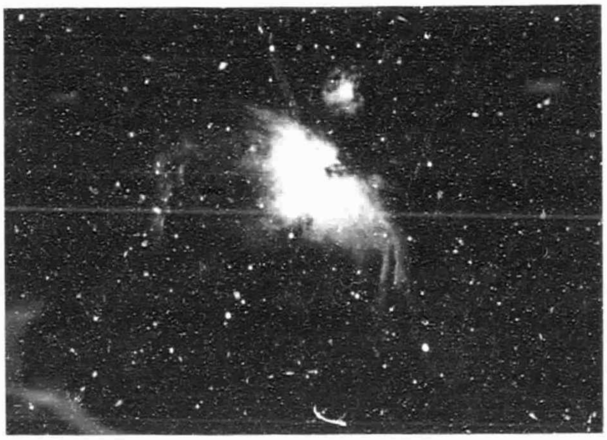
The LDEF is a relatively inexpensive spacecraft. In the past, very sophisticated and expensive spacecraft have been required for scientific experimentation in space. The experiments have had to rely on telemetry and complex systems to transmit data back to Earth. LDEF dramatically reduces costs because it allows experiments to be accomplished with very inexpensive flight hardware. Its retrievability eliminates the need for expensive telemetry to transmit data, and because it uses gravity for stabilization, it doesn't require a propulsion system and has no need for equipment to keep it on course.

LDEF is reusable and can be filled with new experiment trays for subsequent missions, which could occur about every 18 months.

Understanding Our Cosmic Origins

A number of LDEF experiments should unlock some of the secrets of space and provide valuable information about our universe and its origins. These experiments will obtain samples for postflight laboratory study of cosmic dust, interstellar gases and even previously unobtainable subatomic radiation particles. Each of these samples can contribute unique information to guide scientists to make better models of the creation and evolution of our universe.

The comets and planets were probably formed from the same primordial gas and dust reservoir. The original dust, which contributed to the build up of our Earth and the other planets in our solar system, has been significantly altered and no longer resembles the original material. Comets, on the other hand, have spent most of their life in the frozen depths of outer space; and thus the dust which resulted in their buildup has escaped many of the external processes that have altered the planets. LDEF will fly experiments to capture cometary dust. The postflight laboratory analysis of this dust will reveal both its chemical and isotopic composition — important keys to its creation.



By sampling and studying space matter, such as cosmic dust, cosmic rays and interstellar gases, LDEF experiments should provide new insight into the origin and evolution of our universe. Shown here is the Orion Nebula, a huge mass of interstellar dust and gas.

There are many theories as to how our universe evolved. Many of these theories are based on the observed abundance of various elements and isotopes in the small sample of material that has been observed from our solar system. The LDEF will fly the Interstellar Gas Experiment to obtain samples of gases that originated outside our solar system. Postflight analysis of the abundance of isotopes of the inactive gases present in the samples will provide new data for the evaluation of current theories of the origin and evolution of the Universe. Scientists should gain insight into the nucleosynthetic (element building) processes that have occurred in the evolutionary process.

Much of the radiation encountered in space is, in fact, the encountering of subatomic particles. Cosmic rays, for example, are the nuclei of atoms traveling through space at speeds approaching the speed of light.

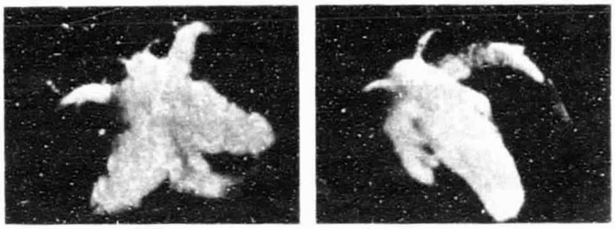
LDEF's Ultra-Heavy Cosmic Ray Nuclei Experiment will gather data which can be used in determining the relative abundance of ultra-heavy nuclei of elements varying in density from zinc to uranium. The relative abundance of these nuclei is important in identifying the specific processes that took place in the creation and evolution of the universe. These ultra-heavy nuclei are rare in space. Because of its size and the length of its mission, LDEF will gather ten times more data on these nuclei than has been gathered by all experiments performed to date. In addition to providing a better understanding of how our universe evolved, this experiment may reveal currently unknown nuclei processes.

Determining The Long-Term Effects of the Space Environment on Living Things

Space is still a new frontier for man, for he has spent relatively little time beyond the confines of his planet. The longest time period that any United States' astronauts have logged in space occurred during the 84-day mission of Skylab 4 in 1973. There is much to be learned about the nature of the environment of outer space and the effects of prolonged exposure on the people, materials and equipment sent there. Because it is impossible to duplicate the space environment on Earth, the only viable laboratory for studying the space environment is in space itself.

Radiation is a natural phenomenon present in space. As people spend greater periods of time in space, they will be exposed to larger doses of radiation. It is known that radiation exposure has a cumulative effect and that substantia ses over time can lead to medical complications. Because it is impractical to increase the thickness of spacecraft for greater shielding, it is critical that we understand the kinds and levels of radiation to which humans in space will be exposed. Radiation, in fact, may ultimately be the deciding factor on how long a person may stay in space.

LDEF's Biostack Experiment will study the effects of radiation on living organisms. Numerous layers of plastic will be stacked with living organisms, including biomolecules and plants. Organisms selected for this experiment had to be small enough to fit into the experiment package and capable of surviving the prolonged period in space. In postflight analysis, researchers will be able to trace the path of the nuclei striking the experiment and also to analyze the effects of radiation on the organisms. For example, the shrimp eggs being flown on this experiment will later be cultivated. Scientists will be able to identify which eggs have been struck by c smic rays and to determine what impact this encounter has had on the developing organism.



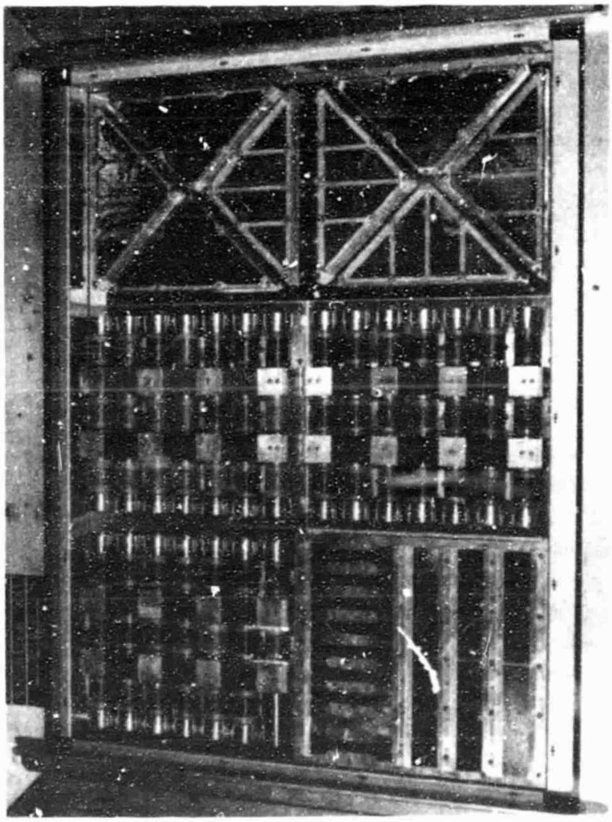
These deformed shrimp were grown from eggs flown aboard the Apollo 17 mission. LDEF's Biostack Experiment will determine the long-term effects of space exposure on shrimp eggs and other living organisms.

Long-Term Effects of the Space Environment on Materials and Hardware

A substantial number of LDEF experiments are designed to gather information on how materials, coatings, electronic parts and thermal control systems are affected by exposure to the space environment. LDEF offers a unique opportunity to measure the effects of environmental factors such as radiation, vacuum, extreme temperatures and collision with space matter. Researchers know from experience that materials and hardware used in spacecraft degrade over time and this degrading impacts the validity of data being transmitted. Prior to making a significant economic investment in large space structures or space stations, engineers must understand how structural and mechanical properties of materials and coatings change over time in space so they can assure their durability in space for time periods of up to 20 years or longer.

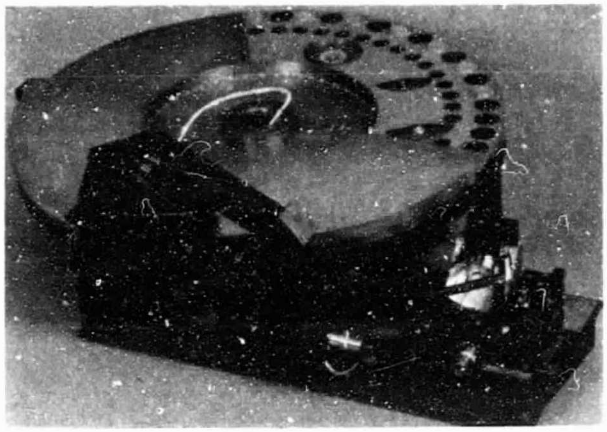
Monitoring the Earth's thermal balance is critical to life on Earth. Changes in the Earth's energy balance — called the Earth radiation budget — could result in changes in climate and growing seasons, as well as increased incidence of skin cancer.

Solar and thermal radiation detectors on past Earth radiation budget satellites have degraded over time in space, changing the sensitivity of spacecraft instruments and causing the generation of incorrect data. One LDEF experiment will expose instruments like those used on previous Earth radiation budget satellites to the space environment. Researchers hope to learn more about what causes the degradation so that future instruments can be built to assure greater stability.



Polymer Matrix Composite Materials Experiment

A number of experiments will expose a wide variety of composite materials to the space environment. Composites, plastic materials with extremely high-strength fibers placed inside, are planned for use in the building of space platforms, space stations and other space structures because they are lighter and stronger than metals. These experiments will provide critical information on the durability of composites in space.



The Thermal Control Surfaces Experiment is a flying laboratory which takes daily measurements of surface changes in 25 samples of thermal control materials.

Coatings, such as paints and other insulative materials, act as passive thermal controls in helping spacecraft systems maintain their required operating temperatures. The integrity of coatings is essential to spacecraft function. Changes in absorptivity and emissivity of the coatings, caused by such factors as atomic oxygen impingement and radiation, can radically affect system performance. Several LDEF experiments will provide long-term space exposure for a wide variety of coatings.

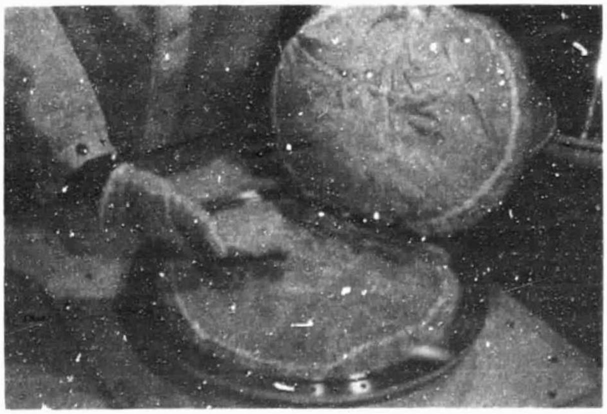
The atomic oxygen present in space degrades materials, often causing surface erosion and changed surface characteristics. One experiment will expose select thermal control surfaces to atomic oxygen in near-Earth orbit. By analyzing exposed samples, investigators will get a clearer picture of the effects of atomic oxygen. This data will be helpful in assuring the flight worthiness of future Shuttle payloads, such as the Space Telescope and the High Energy Astronomy Observatory.

Active Optical Systems Components Experiment

Other materials experiments deal with dosimeters (radiation detectors), semi-conductors, mirrors, lenses, polymer films, fiber optics and balloon materials. The effects of long duration exposure on active optical systems components, such as cameras, lamps and laser tubes, will also be studied.

Seeds In Space - An Opportunity For Student Investigation

Upper elementary through university level students will have an exciting opportunity for first-hand experimentation with tomato seeds flown aboard LDEF.



Packaged tomato seeds being placed in canisters for the Space Exposed Experiment Developed for Students.

Approximately twelve million seeds, packaged in dacron bags and sealed in aluminum canisters, will be flown in the SEEDS (Space Exposed Experiment Developed for Students) tray. An equivalent number of seeds from the same seed lot will be stored in a ground-based facility and will serve as the control seeds. All seeds were provided by the Park Seed Company of Greenwood, S.C.

After the LDEF is retrieved from orbit and brought back to Earth, NASA will return the flight seeds to Park Seed Company for analysis and subsequent packaging into laboratory kits for educational use. Each kit will contain 50 control seeds and 50 flight seeds, along with at least one recommended experiment. Students will be able to use the seeds to design their own experiments.

A wide variety of experimental possibilities exist using the flight and control seeds. Germination rates, seed embryos, phototropic reactions and fruit products may be compared. Students could also consider the impact of changes in environmental factors, such as water, humidity, soil and pollutants. University students could perform chromosome studies and studies of hormonal and growth regulators.

The program encourages active student involvement and a multidisciplinary approach. It allows students to design their own experiments and to be involved in decision making, data gathering and reporting of final results.

Tomato seeds were selected because their small size permitted large quantities to be flown in a relatively small area and because tomatoes are a plant type familiar to all areas of the United States. Also, they are relatively simple to germinate and grow.

Information on how educators can obtain the kits will be disseminated during the 1984-85 school year through professional meetings and educational journals. The kits will be distributed during the fall of 1985. During the spring of 1986, students will be asked to report their results back to NASA, which will issue a summary report for distribution to all SEEDS participants.

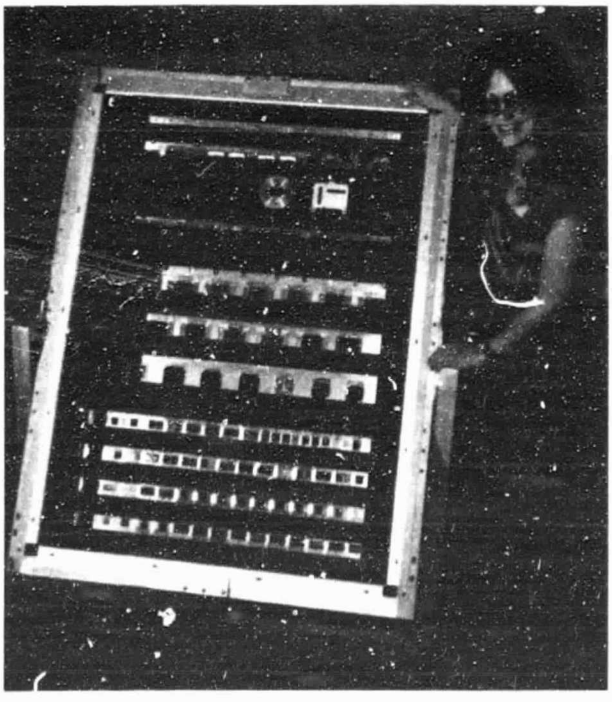
Power Generation In Space

Electrical power is critical to the function of most spacecraft. Once most spacecraft achieve orbit, they require electricity for activities such as experiment operation and data transmission.

Solar cells, which harness solar energy and convert it to electricity, have proven to be a very effective means of generating power in space. Small, lightweight and relatively inexpensive, they convert the Sun's energy to meet spacecraft electrical needs.

As experiments become more complex, so do their power requirements. Space experimentation in the future will place even greater demands on solar cells.

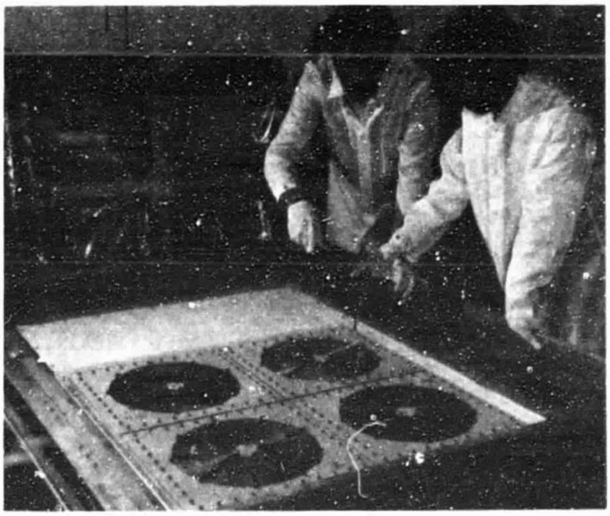
Because solar cells must remain relatively unshielded to be effective, they are particularly vulnerable to the degrading effects of space (radiation, particulate contamination, etc.) which result in decreased efficiency. One LDEF experiment will attempt to determine the effects of space on solar cells and components such as covers, adhesives and encapsulants. Preflight and postflight measurements of chemical, electrical and optical properties of these materials will help researchers evaluate the effects of long-term space exposure.



Advanced Photovoltaic Experiment

The Advanced Photovoltaic Experiment will determine the performance and endurance of advanced solar cell designs under space conditions. This highly sophisticated flying laboratory will provide a time history of cell performance in space. Data recorded in this experiment will provide information for solar cell calibration to assure accurate results over time in space.

Spacecraft encounter streams of charged particles as they move through space. These particles act as conductors, draining electrical power and sometimes causing arcing, which can result in a loss of energy from arrays of solar cells. The Space Plasma - High Voltage Drainage experiment will study this phenomenon by subjecting samples of nonconductive materials used in solar arrays to high voltage fields in space to determine their in-space current drainage behavior. After postflight analysis, researchers hope to be able to specify allowable voltage levels for the tested materials when they receive prolonged use in space.

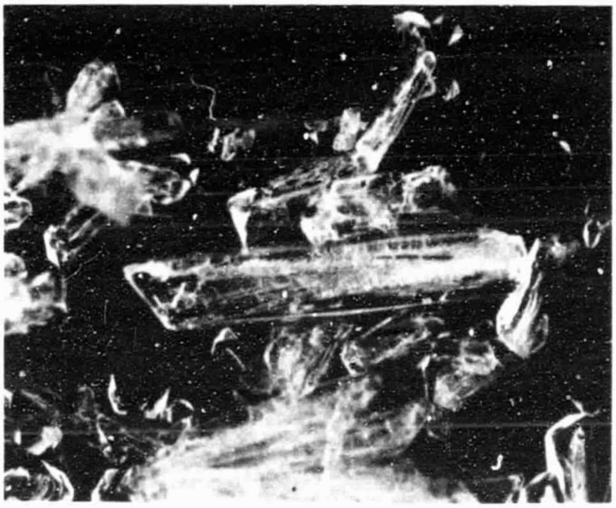


Fiber Optic Data Transmission Experiment shown during reception and inspection activity.

Fiber optic materials have potential use on spacecraft in place of conductors in electrical systems. In an effort to assure the invulnerability of fiber optics systems to radiation, NASA and the Department of Defense are flying fiber optic cables on LDEF to see how the space environment may affect the accuracy of data transmission.

Experimentation With Crystals

Crystals, extensively used in integrated circuitry, need to be of high purity. Because the production of pure crystals is greatly improved in a gravity-free environment, space provides the perfect medium for their growth.



These calcium tartrate crystals were grown in space during the Apollo-Soyuz Test Project. Experiments on the growth of lead sulfide, calcium carbonate and TTF-TCNQ crystals in space will be flown aboard the first LDEF mission.

Some crystal experiments have flown already on Shuttle missions. Those being flown aboard the first LDEF mission will be able to grow crystals for a longer period and will result in crystals of greater size.

Tiny crystal wafers used to store information will be part of another crystal experiment. Lasers are used to write information on the crystal, which is later read by a 3-D illuminating light source. These wafers can store enormous quantities of data – approximately 10^{11} bits of information in an area the size of a fingernail. Researchers will be studying how the crystals and their stored data might degenerate during the exposure period.

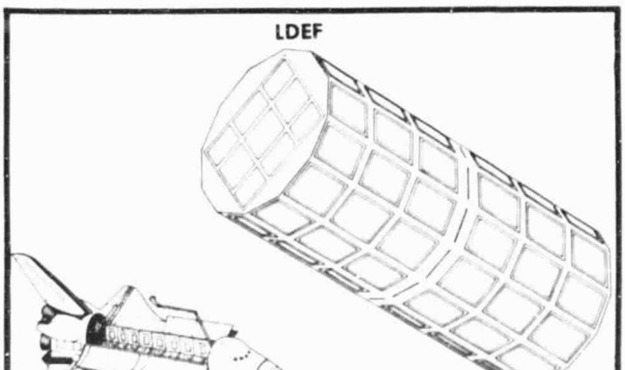
Another experiment will study the effect of orbital radiation on quartz crystal oscillators. These oscillators, used as clocks on satellites, often experience frequency drift caused by space radiation. This experiment should lead to a better understanding of the frequency drift problem.

Thermal Control Experiments

Several LDEF experiments test a relatively simple device called a heat pipe to assure precise temperature control.

A heat pipe is a mechanism that operates to transfer heat or cold from one spacecraft component to another. It uses a substance, such as ammonia or ethanol, which is a liquid at the cool end of the pipe and a gas at the hot end. The substance naturally moves back and forth along a wick to transfer heat and cold as needed.

A number of spacecraft applications could benefit from such a precise temperature control system that requires no electrical power. Several LDEF experiments will evaluate the performance capability of different heat pipe designs. Heat pipes work most efficiently in the zero-gravity environment of space which provides the ultimate test environment for these devices.



Summary

The Long Duration Exposure Facility will explore the space environment for future long duration space missions. It is a test bed for materials and system components to be used in future spacecraft and space station missions.

This mission will reveal something of man's cosmic roots and perhaps provide insight into the future of our solar system. The knowledge gained from LDEF's experiments will have far reaching implications on man's future in space and should result in new technology that will improve his life on Earth.

LDEF Experiments and Principal Investigators

Materials, Coating and Thermal Systems

GROWTH OF CRYSTALS FROM SOLUTIONS IN LOW GRAVITY - M. David Lind, Rockwell International Science Center, and Kjeld F. Nielsen, Technical University of Denmark.

ATOMIC OXYGEN STIMULATED OUTGASSING - Robert L. Scott, Jr., Southern University and Roger C. Linton, NASA Marshall Space Flight Center.

THE INTERACTION OF ATOMIC OXYGEN WITH SOLID SURFACES AT ORBITAL ALTITUDES - John C. Gregory, University of Alabama in Huntsville, and Palmer N. Peters, NASA Marshall Space Flight Center.

INFLUENCE OF EXTENDED EXPOSURE IN SPACE ON MECHANICAL PROPERTIES OF HIGH-TOUGHNESS GRAPHITE-EPOXY COMPOSITE MATERIAL - David K. Felbeck, University of Michigan.

EFFECT OF SPACE EXPOSURE ON SPACE BASED RADAR PHASED ARRAY ANTENNA - Richard J. Delasi, Martin L. Rossi, James B. Whiteside, Martin Kesselman, Ronald L. Heuer, and Frederick J. Kuehne, Grumman Aerospace Corporation.

EFFECT OF SPACE EXPOSURE ON SOME EPOXY MATRIX COMPOSITES ON THEIR THERMAL EXPANSION AND MECHANICAL PROPERTIES - Robert Elberg, S.A. Matra, France.

SPACE EXPOSURE OF COMPOSITE MATERIALS FOR LARGE SPACE STRUCTURES - Wayne S. Slemp, NASA Langley Research Center.

EFFECT OF THE SPACE ENVIRONMENT ON COMPOSITE MATERIALS - Michel Parcelier, Aerospatiale, France.

MICROWELDING OF VARIOUS METALIC MATERIALS UNDER ULTRA VACUUM - Jean Pierre Assie, Aerospatiale, France.

EVALUATION OF LONG-DURATION EXPOSURE TO THE NATURAL SPACE ENVIRONMENT ON GRAPHITE/POLYIMIDE AND GRAPHITE/EPOXY MECHANICAL PROPERTIES - J. Howard Powell and Douglas W. Welch, Rockwell International Corporation.

THE EFFECT OF SPACE ENVIRONMENT EXPOSURE ON THE PROPERTIES OF POLYMER-MATRIX COMPOSITE MATERIAL - R.C. Tennyson and J.S. Hansen, Institute for Aerospace Studies, University of Toronto.

SPACE ENVIRONMENT EFFECTS ON SPACECRAFT MATERIALS - Paul Schall, The Aerospace Corporation and 22 coinvestigators.

BALLOON MATERIALS DEGRADATION - David H. Allen, Texas A&M University.

THERMAL CONTROL COATINGS EXPERIMENT - A. Paillous, CERT/ONERA-DERTS, France, and J.C. Guillavmon, CNES/CST, France.

EXPOSURE OF SPACECRAFT COATINGS - Wayne S. Slemp, NASA Langley Research Center.

THERMAL CONTROL SURFACES EXPERIMENT - Donald R. Wilkes and Harry M. King, NASA Marshall Space Flight Center

ION BEAM TEXTURED AND COATED SURFACES EXPERIMENT - Michael J. Mirtich, Jr., NASA Lewis Research Center.

CASCADE VARIABLE CONDUCTANCE HEAT PIPE - Michael G. Grote and Leslie D. Calhoun II, McDonnell Douglas Astronautics Company.

LOW TEMPERATURE HEAT PIPE EXPERIMENT PACKAGE FOR LDEF - Roy McIntosh, Jr., and Stanford Ollendorf, NASA Goddard Space Flight Center; and Craig R. McCreight, NASA Ames Research Center.

TRANSVERSE FLAT PLATE HEAT PIPE EXPERIMENT - James W. Owen, NASA Marshall Space Flight Center, and Fred Edelstein, Grumman Aerospace Corporation.

LDEF THERMAL MEASUREMENTS SYSTEM - Robert F. Greene, Jr., NASA Langley Research Center.

Power and Propulsion

SPACE PLASMA-HIGH VOLTAGE DRAINAGE EXPERIMENT - William W.L. Taylor and Gene K. Komatsu, TRW Space and Technology Group.

SOLAR ARRAY MATERIALS PASSIVE LDEF EXPERIMENT - Ann F. Whitaker, Charles F. Smith, Jr., and Leighton E. Young, NASA Marshall Space Flight Center; Henry W. Brandhorst, Jr., and A.F. Forestieri, NASA Lewis Research Center; Edward M. Gaddy and James A. Bass, NASA Goddard Space Flight Center; and Paul M. Stella, Jet Propulsion Laboratory.

ADVANCED PHOTOVOLTAIC EXPERIMENT - Henry W. Brandhorst, Jr., and A.F. Forestieri, NASA Lewis Research Center.

INVESTIGATION OF CRITICAL SURFACE DEGRADATION EFFECTS ON COATINGS AND SOLAR CELLS DEVELOPED IN GERMANY - Ludwig Preuss, Messerschmitt-Bolkow-Blohm, Space Division, Federal Republic of Germany.

SOLID ROCKET MATERIALS SPACE AGING EXPERIMENT - Leon L. Jones, Morton Thiokol Inc.

Science

INTERSTELLAR GAS EXPERIMENT - Don L. Lind, NASA Johnson Space Center; and Johannes Geiss and Fritz Buhler, University of Bern, Switzerland.

A HIGH RESOLUTION STUDY OF ULTRA-HEAVY COSMIC RAY NUCLEI - Denis O'Sullivan, Alex Thompson and Cormac O'Ceallaigh, Dublin Institute for Advanced Studies, Ireland; and Vicente Domingo and Klaus-Peter Wenzel, European Space Agency, ESTEC, The Netherlands.

HEAVY IONS IN SPACE - Maurice M. Shapiro, James H. Adams, Jr., Rein Silberberg and C.H. Tsao, Naval Research Laboratory.

TRAPPED PROTON ENERGY SPECTRUM DETERMINATION - Frederick J. Rich and Irving Michael, Air Force Geophysics Laboratory; Gerald J. Fishman, NASA Marshall Space Flight Center; Paul L. Sagalyn, Army Materials & Mechanics Research Center; Peter J. McNulty, Clarkson College of Technology; Y.V. Rao, Emmanuel College; and Christopher E. Laird, Eastern Kentucky University.

MEASUREMENT OF HEAVY COSMIC RAY NUCLEI ON LDEF - Rudolf Beaujean, Wolfgang Enge and Georg Siegmon, Kiel University, Federal Republic of Germany.

RADIATION DOSE AND LET SPECTRA MEASUREMENTS - Eugene V. Benton, University of San Francisco, and Thomas A. Parnell, NASA Marshall Space Flight Center.

MULTIPLE FOIL MICROABRASION PACKAGE - J.A.M. McDonnell, D.G. Ashworth, W.C. Carey, R.P. Flavill and R.C. Jennison, University of Kent, United Kingdom.

STUDY OF METEOROID IMPACT CRATERS ON VARIOUS MATERIALS - J-C. Mandeville, CERT/ONERA-DERTS, France.

ATTEMPT AT DUST DEBRIS COLLECTION WITH STACKED DETECTORS - J-C. Mandeville, CERT/ONERA-DERTS, France.

THE CHEMISTRY OF MICROMETEOROIDS - Friedrich Horz, David S. McKay, and Donald A. Morrison, NASA Johnson Space Center; Donald E. Brownlee, University of Washington; and Robert M. Housley, Rockwell International Science Center.

CHEMICAL AND ISOTOPIC MEASUREMENTS OF MICROMETEOROIDS BY SECONDARY ION MASS SPECTROMETRY - John Foote, Patrick Swan, Robert M. Walker, and Ernst Zinner, McDonnell Center for the Space Sciences; Dieter Bahr, Hugo Fechtig, and Elmar Jessberger, Max-Planck Institut fur Kernphysik, Federal Republic of Germany; Eduard Igenbergs, Uwe Kreitmayr, and Heribert Kuczera, Technische Universitat Munchen, Federal Republic of Germany; Eberhard Schneider, Ernst-Mach-Institut, Federal Republic of Germany; and Norbert Pailer, Dornier System GmbH, Federal Republic of Germany.

INTERPLANETARY DUST EXPERIMENT - S. Fred Singer and John E. Stanley, University of Virginia, and Philip C. Kassel, Jr., NASA Langley Research Center.

SPACE DEBRIS IMPACT EXPERIMENT - Donald H. Humes, NASA Langley Research Center.

METEOROID DAMAGE TO SPACECRAFT - Consortium of Investigators.

FREE FLYER BIOSTACK EXPERIMENT - Horst Bucker, DFVLR, Institute for Flight Medicine, Federal Republic of Germany, and 37 coinvestigators.

SEEDS IN SPACE - George B. Park, Jr., and Jim A. Alston, George W. Park Seed Company, Inc.

SPACE EXPOSED EXPERIMENT DEVELOPED FOR STUDENTS (SEEDS), Doris Grigsby, Experiment Coordinator, NASA Headquarters.

Electronics and Optics

HOLOGRAPHIC DATA STORAGE CRYSTALS FOR THE LDEF - W. Russell Callen and Thomas K. Gaylord, Georgia Institute of Technology.

EXPOSURE TO SPACE RADIATION OF HIGH PERFORMANCE INFRARED MULTILAYER FILTERS AND MATERIALS TECHNOLOGY EXPERIMENTS - John S. Seeley, R. Hunneman and A. Whatley, University of Reading, United Kingdom; and D.R. Lipscombe, British Aerospace Corporation, United Kingdom.

EFFECT OF SPACE EXPOSURE ON PYROELECTRIC INFRARED DETECTORS - James B. Robertson, Ivan O. Clark, and Roger K. Crouch, NASA Langley Research Center.

THIN METAL FILM AND MULTILAYERS EXPERIMENT - J.P. Delaboudiniere and J.M. Berset, CNRS/LPSP, France.

VACUUM-DEPOSITED OPTICAL COATINGS EXPERIMENT - A. Malherbe, MATRA/SFOM Optical Division, France.

RULED AND HOLOGRAPHIC GRATINGS EXPERIMENT - Gilbert Moreau, Instrument SA/JOBIN-YVON Division, France.

OPTICAL FIBERS AND COMPONENTS EXPERIMENT - J. Bourrieau, CERT/ONERA-DERTS, France.

PASSIVE EXPOSURE OF EARTH RADIATION BUDGET EXPERIMENT COMPONENTS - John R. Hickey and Francis J. Griffin, The Eppley Laboratory Inc.

EFFECT OF SOLAR RADIATION ON GLASSES - Ronald L. Nichols, NASA Marshall Space Flight Center, and Donald L. Kinser, Vanderbilt University.

STUDY OF FACTORS DETERMINING THE RADIATION SENSITIVITY OF QUARTZ CRYSTAL OSCILLATORS - John D. Venables and John S. Ahearn, Martin Marietta Laboratories.

INVESTIGATION OF THE EFFECTS OF LONG-DURATION EXPOSURE ON ACTIVE OPTICAL SYSTEM COMPONENTS - M. Donald Blue, James J. Gallagher, and R.G. Shackelford, Georgia Institute of Technology.

FIBER OPTIC DATA TRANSMISSION EXPERIMENT - Alan R. Johnston and Larry A. Bergman, Jet Propulsion Laboratory.

SPACE ENVIRONMENT EFFECTS ON FIBER OPTICS SYSTEMS - Edward W. Taylor, Air Force Weapons Laboratory.

SPACE ENVIRONMENT EFFECTS - Joseph A. Angelo, Jr., and Richard G. Madonna, Air Force Technical Applications Center; Lynn P. Altadonna, Perkin-Elmer; Michael D. D'Agostino and Joseph Chang, Grumman Aerospace Corporation; and R.R. Alfano and Van L. Caplan, The City College, New York City.

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